(2)

AD-A163 181

REPORT DOCUMENTATION PAGE

1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFGL-TR-86-0003
6a. NAME OF PERFORMING ORGANIZATION Air Force Geophysics Laboratory	6b. OFFICE SYMBOL (If applicable) OPA
7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State and ZIP Code) Hanscom AFB Massachusetts 01731	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State and ZIP Code)	

10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
62101F	7670	14	02

11. TITLE (Include Security Classification) Optical and Radiative Properties of a Desert Aerosol Model

12. PERSONAL AUTHOR(S)
Eric P. Shettle

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Scientific Interim	FROM ______ TO ______	3 January 1986	4

16. SUPPLEMENTARY NOTATION Reprinted from: IRS 84: Current Problems in Atmospheric Radiation Proceedings of the International Radiation Symposium, Perugia, Italy 21-28 Aug 84, Edited by Giorgio Fiocco

17. COSATI CODES

FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Desert Aerosols, Optical Properties, Scattering, Transmission, Atmospheric Radiation

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Experts Meeting on Aerosols and their Climatic Effects, under the World Climate Research Program reviewed the status of the aerosol models in the Standard Radiation Atmospheres of the IAMAP Radiation Commission. One of the major areas for improving these aerosol models was identified as the need for a separate desert aerosol model. Several recommendations were made for developing such an aerosol model. A desert aerosol model based on these recommendations and other work will be discussed with emphasis on the optical and radiative properties and their variations with wind speed.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☒ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Eric P. Shettle	22b. TELEPHONE NUMBER (Include Area Code) (617) 861-3665
22c. OFFICE SYMBOL OPA	

2

AFGL-TR-86-0003

OPTICAL AND RADIATIVE PROPERTIES OF A DESERT AEROSOL MODEL

E.P. Shettle
Air Force Geophysics Laboratory
Hanscom AFB, Massachusetts, USA

Introduction

One of the major sources of the natural atmospheric aerosols is wind-blown dust and sand. These predominantly originate from the arid and semi-arid regions which make up one-third of the earth's land area (~~e.g. see Levin et al., 1980~~). The aerosol models in the Standard Radiation Atmospheres (SRA) of the IAMAP Radiation Commission, do not include a model specifically representative of these regions. For this reason the Experts Meeting on Aerosols and their Climatic Effects (WMO 1983), under the World Climate Research Program, identified as one of the major areas for improving the SRA aerosol models, the need for a separate desert aerosol model. Several recommendations were made for developing such an aerosol model. This paper presents the optical and radiative properties of a desert aerosol model based on those recommendations. Two models are discussed representing the extremes of background conditions and a severe dust storm.

Separate desert

to 1473

Physical Properties of the Desert Aerosols

The refractive index of the aerosols is based on the work of Volz (1973), Benjamin & Carlson (1980) and Patterson (1981), as discussed below. The real part of the refractive index follows Carlson & Benjamin (1980) for wavelengths, $\lambda \leq 2.5$ µm. For longer wavelengths Volz's (1973) measurements from the real part are used. The imaginary part of the refractive index is based on Benjamin and Carlson (1980) for $\lambda \leq 1.0$ µm, and is joined smoothly into an average of Volz's (1973) and Patterson's (1981) measurements for imaginary part, which are in good agreement with recent measurements (Fouquart, et al., 1984).

The size distribution is based on the review by Jaenicke (1983). The size distributions for the aerosol models are represented as the sum of 3 log-normal distributions:

$$\frac{dN(r)}{d\log r} = \sum_{i=1}^{3} \frac{N_i}{\sqrt{2\pi}\,\log\sigma_i}\exp - \frac{(\log r - \log R_i)^2}{2(\log\sigma_i)^2}$$

where $N(r)$ = particle concentration for particles with radius > r.
N_i = total number of particles in the i^{th} distribution
σ_i = geometric standard deviation
R_i = mode radius

The values of the parameters N_i, σ_i, and R_i are summarized in Table 1, following WMO, 1983 (their Table 4.1). The number density distribution for these models is shown in Figure 1 and the cross-sectional area distribution is shown in Figure 2. It will be noted that the two model size distributions differ significantly only for the larger aerosols.

Optical and Radiative Properties

The optical and radiative properties were derived from standard Mie scattering calculations. Figure 3 shows our results for the extinction, scattering and absorption coefficients for the Background Desert Aerosol Model and Figure 4 shows the corresponding results for the Desert Dust Storm Model. The extinction coefficients for the two models are shown in Figure 5. It will be noted that the Desert Dust Storm Aerosol Model extinction excedes the Background Model values by a factor of 40 in the visible and by 3 orders of magnitude in the far IR. This is due to the enhanced numbers of very large aerosols with severe wind conditions. The single scatter albedo (the ratio of scattering to total extinction) is shown in Figure 6, for the two models.

The asymmetry parameter, which characterizes the angular distribution of the scattered radiation is shown in Figure 7.

References

Carlson, T.N. & S.G. Benjamin (1980), "Radiative Heating Rates for Saharan Dust", J. Atmos. Sci., 37, 193-213.

Fouquart, Y. B. Bonnell, A. Cerf, M. Chaoui, L. Smith, & J.C. Vanhoutte (1984) "Size Distribution and Optical Properties of Saharan Aerosols during ECLATS", in Aerosols and Their Climatic Effects, edited by A. Deepak & H. Gerber, A. Deepak Publishing, in press.

Jaenicke, R. (1983), Presented at the Experts Meeting on Aerosols and Their Climatic Effects (WMO 1983), also to be published in "Aerosol Physics and Chemistry" Meteorology Volume in Landolt-Bornstein.

Levin, Z., J.H. Joseph, & Y. Mekler (1980), Properties of Sharav (Khamsin) Dust - Comparison of Optical and Direct Sampling Data", J. Atmos. Sci., 37, 882-891.

Patterson, E.M. (1981), "Optical Properties of the Crustal Aerosol; Relationship to Chemical and Physical Characteristics", J. Geophys. Res., 86, 3236-3246.

Volz, F.E. (1973), "Infrared Optical Constants of Ammonium Sulfate, Saharan Dust, Volcanic Pumice, and Flyash", Appl. Opt., 12, 564-567.

WMO (1983) "Report of the Experts Meeting on Aerosols and their Climatic Effects" (Williamsburg, VA, 28-30 March 1983), World Climate Research Programme, Report No. WCP-55, Published by the World Meteorological Organization, Dec 1983.

TABLE 1 Parameters for Desert Aerosol Size Distribution

Size Distribution	i	N_i (cm^{-3})	σ_i	R_i (μm)
Background Desert Model	1	9.97×10^{2}	0.328	0.0010
	2	8.42×10^{2}	0.505	0.0218
	3	7.10×10^{-4}	0.277	6.24
Desert Dust Storm Model	1	7.26×10^{2}	0.247	0.0010
	2	1.14×10^{3}	0.770	0.0188
	3	1.78×10^{-1}	0.438	10.8

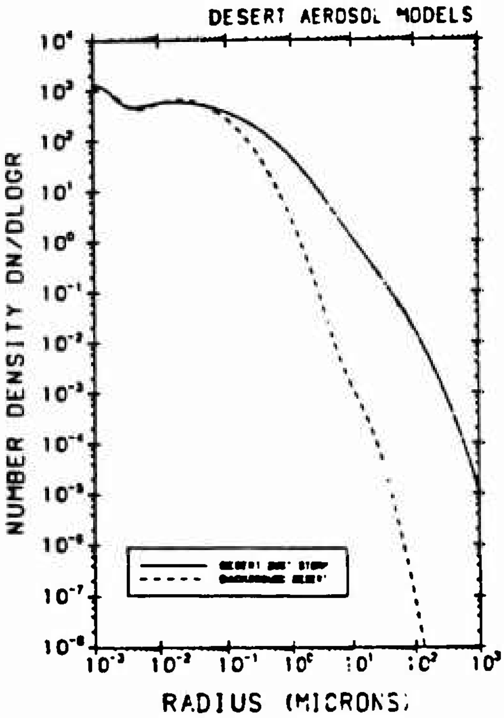

Figure 1. Number Density Distribution (particle/cm^3) for the Desert Aerosol Models.

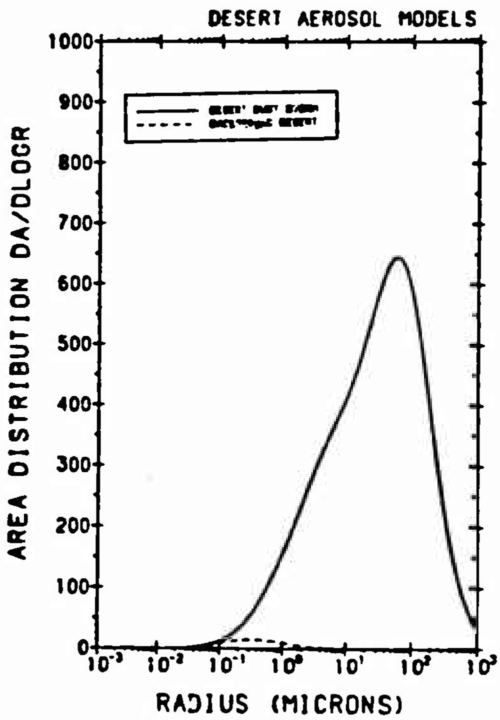

Figure 2. Area Distribution ($\mu m^2/cm^3$ for the Desert Aerosol Models.

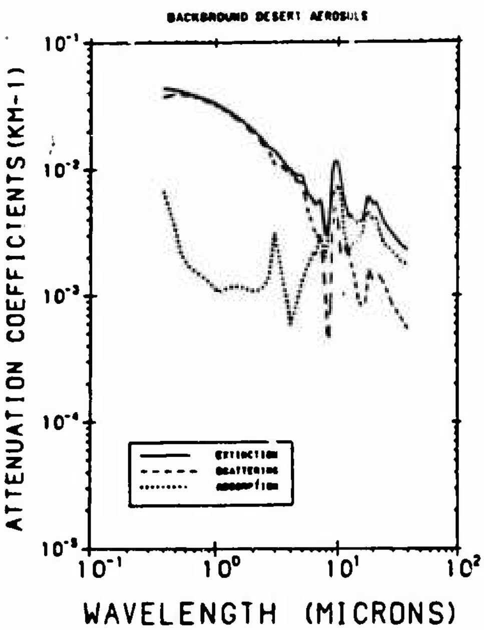

Figure 3. The Attenuation Coefficients for the Background Desert Aerosol Model as a Function of Wavelength.

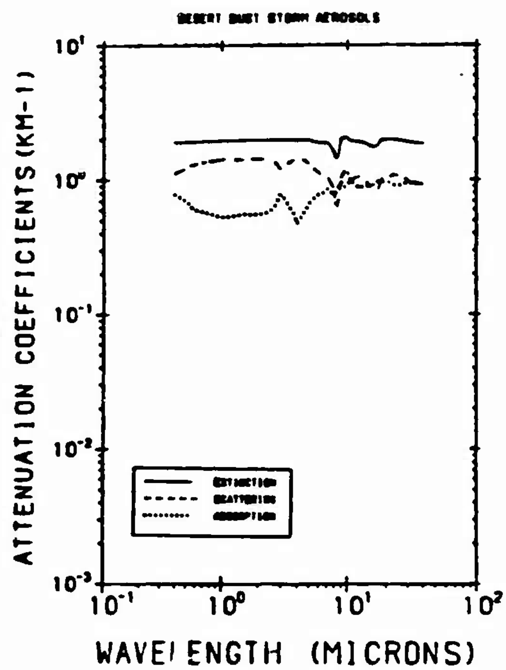

Figure 4. The Attenuation Coefficients for the Desert Dust Storm Aerosol Model as a Function of Wavelength.

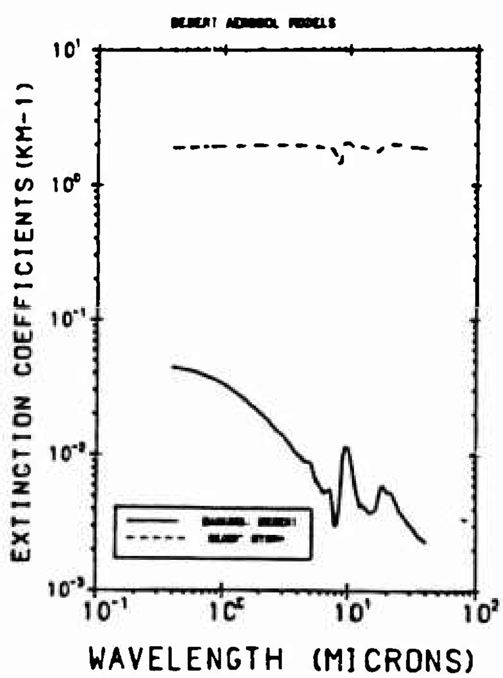

Figure 5. Comparison between the Extinction for the Background Desert and the Desert Dust Storm Aerosol Models.

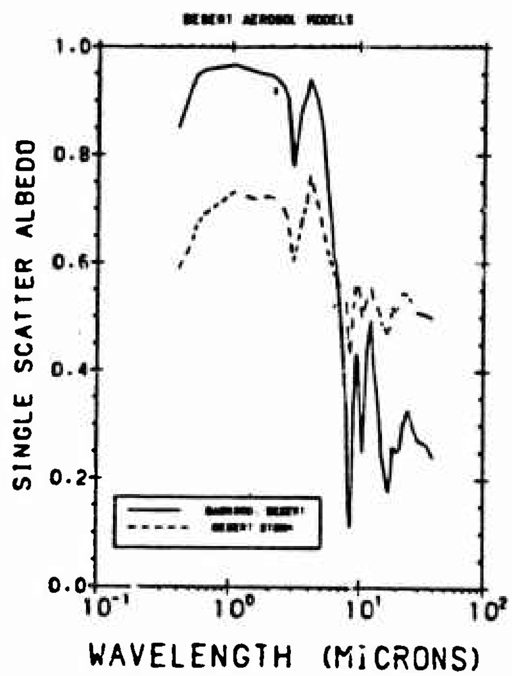

Figure 6. Comparison between the Albedo for Single Scattering for the Background Desert and the Desert Dust Storm Aerosol Models.

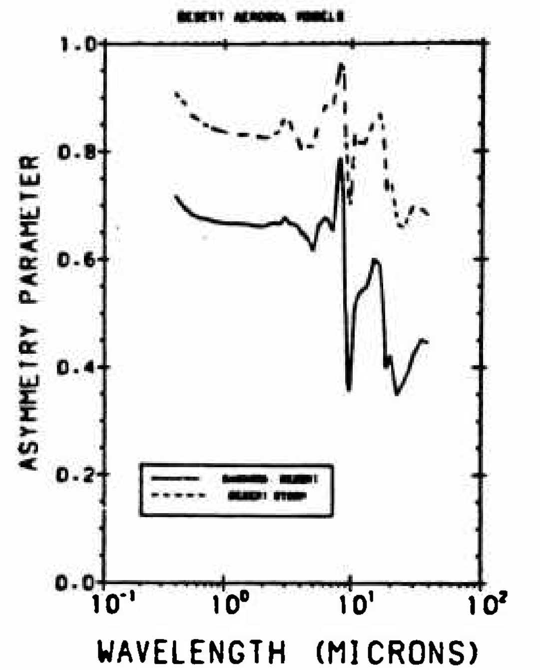

Figure 7. Comparison between the Asymmetry Parameter for the Background Desert and the Desert Dust Storm Aerosol Models.